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**FRESHNESS MEASUREMENTS ON COD AND REDFISH WITH THE RT FRESHNESS GRADER**

By Emilía Martinsdóttir

## 1. Introduction

The firm of Rafagnatækni in Reykjavík has been working for some time on the development and construction of equipment which has recently entered the market as the RT freshness grader. These machines are intended for the grading of fish by freshness and are based on the method of assessment of the ~~so-called~~ Torry measuring device but detect changes in electrical properties, conductivity and volume coefficients which occur after the fish is killed and shows signs of spoilage. Developed at the Torry Research Station in Scotland and introduced to this country about 1970, the Torry measuring device never achieved significant distribution here. It was slow-working and results did not always agree with physical appraisals. The Torry measuring device was used extensively at the Fishing Industry Research Station in the preparation of courses in appraising and was very useful, especially when each fish was measured repeatedly at different places and a mean was taken of the measurements. Due to the significant advances in electronics in the years since the device was manufactured, the notion arose of accelerating the grading process while measuring each fish at different places and even on the conveyor belt. The Fishing Industry Research Station then asked Rafagnatækni to consider how this could be achieved. In 1982, Rafagnatækni started development of the RT freshness grader. In November 1985, the Fishing Industry Research Station received two prototypes of the freshness grader for testing. The new prototypes and today's freshness graders include weighing equipment and the devices are capable of classifying by freshness and/or weight. Physical appraisal of fish quality is of course not confined to parameters of

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freshness, such as odour, but on the contrary comprises several components such as colour, blood vessels, looseness as well as various handling damage. The RT freshness grader grades fish by freshness as a combination of chemical and bacterial decay in the fish. It is known that physical appraisal, i.e. evaluation of odour, in fresh fish, and taste and odour of boiled fish correlate well with the period of storage on ice. There are also chemical methods for measuring decay in fish. Most frequently used in this country is the measurement of trimethylamine, TMA, which is formed from the substance trimethylamine oxide, TMAO, and represents one of the most significant chemical processes caused by bacteria in fish. TMA increases slowly during the initial days on ice, thereafter more rapidly. Good correlation has been found between odour assessment and TMA measurements. This article describes the key results of investigations made by the Fishing Industry Research Station (R.f.) to verify the freshness grader's ability to measure freshness of cod and redfish. The studies compare the age of fish kept on ice from the day of harvest with freshness measurements made with the RT freshness grader, physical appraisal and TMA analysis.

## 2. Method

Altogether, three experiments were carried out on line-caught cod during November and December, 1985, three experiments on net-caught cod during April and May, 1986, and two on redfish in June and July, 1987. The experiments were carried out at one week's interval. Each experiment included 90 freshly caught fish. Cod were killed on shore. The fish were marked, arranged in boxes, iced and then stored in the station's refrigerator at 1-2°C during the storage experiment. Ice was added to the fish as needed.

At the beginning of each experiment, all fish were measured in the RT freshness grader. Thereafter, 10 fish at a time were measured at intervals of 2-3 days until the experiment was concluded three weeks from date of harvest.

Three appraisers both from the State Ocean Products Inspectorate and the sales cooperative appraised the cod, while five workers from the R.f. appraised the redfish. The primary emphasis was on odour appraisal and five grades were

awarded: excellent, good, reasonable, questionable and unfit. Excellent was awarded for very fresh odour, good represented a fresh and natural odour, reasonable represented dull or no odour, questionable represented an unnatural odour (TMA odour), and unfit represented evidence of acidity, putrescence or rancidity. In the computations, the mark 1 was given for excellent, and 5 for unfit. When compiling the results of the appraisals, the mean of scores obtained by three (or five) appraisers were used in each instance.

## 3. Key results

### 3.1. Measurements on freshly caught fish

The weights and grading results for one- and two-day cod is shown in Table 1.

The standard deviation (SD) of most measurements on the same fish was about 2%, and the standard deviation between measurements on one- and two-day fish from 5 to 10%. Freshness measurements on fresh cod caught in April, and cod caught in November, were on average higher and something should be said about the significance. The report on the Torry grader (1) states that measurement scores for freshly caught cod differ significantly from season to season, reaching a high mark twice during the year, first in April-May and again in December-January, and a low mark in January-February and August-September. We would have liked to see a discussion of this issue here, rather than the discussion on fishing equipment. The same report mentions finding no differences in freshly caught fish by harvest method, provided the fish were handled with reasonable care. Differences in measurement results between net-caught fish bled after death, and live bled fish, have not been recorded.

### 3.2. Correlation between methods

Table 2 shows the correlation coefficients r between days on ice, RT measurements, TMA measurements and physical appraisal. In each case, correlation coefficients are between -1 and 1. If the relationship between the components is perfectly linear, the correlation coefficient is ± 1. If there is no correlation between the components, the correlation coefficient is 0.

The correlation coefficient between TMA measurements (or log 1/TMA) and RT measurements and the period of storage on ice is very high, while correlation between odour appraisal and days on ice, TMA, and RT measurements is low. Correlation between RT measurements and TMA measurements is also high.

### 3.3. Correlation between RT measurements and period of storage on ice

The following equations a-c were used to determine the linearity of relationship between RT measurements and period of storage on ice. Also shown is the explained variation $R^2$. When RT measurements completely reflect the period of storage on ice, the explained variation becomes 100%.

a) For line-caught fish:

$RT = 12.8 - 0.574$ days on ice

$R^2 = 82.5\%$

b) For net-caught fish:

$RT = 14.1 - 0.565$ days on ice

$R^2 = 87.1\%$

c) For redfish:

$RT = 12.3 - 0.369$ days on ice

$R^2 = 83.3\%$

Figure 1 shows the results of RT measurements on line-caught cod compared to the period of storage on ice as well as an optimated line through the points. Figure 2 shows the integrated lines of the above equations for cod and redfish. To compute the equations, results from all three experiments (two for redfish) were used in each instance. When equations are computed independently for each experiment, some differences in coefficients are seen, especially for line-caught fish. Investigation showed that there were significant differences between experiments on line-caught fish. The three experiments should have been totally comparable, but there were certainly some differences as to average fish size. Multiple regression was used to determine whether the weight of the fish had a significant effect on RT measurements. This showed



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that weight partly explained the difference between experiments. Corresponding tests on net-caught fish showed that differences between experiments were not significant and that weight did not have a significant effect. A possible explanation for these results is that the line-caught fish, especially in the first experiment, were much larger than in the others and of very variable size; possibly fish size, i.e. due to the shape of the fish, may have had some influence on RT measurements. Weight did not significantly influence the results of RT measurements in the redfish experiments, and variation between experiments was insignificant.

### 3.4. Correlation between TMA measurements and period of storage on ice

TMA (trimethylamine) in fish increases very little during the initial days on ice, but thereafter rises much more rapidly. Application of log 1/TMA against days on ice showed a high correlation coefficient and we can take a linear relationship for granted. The following equations d-f were used to demonstrate the relationship between TMA measurements and the period of storage on ice. The explained variation $R^2$ is also shown.

d) For line-caught fish:

$$\log 1/TMA = 0.65 - 0.10 \text{ days on ice}$$

$$R^2 = 87.2\%$$

e) For net-caught fish:

$$\log 1/TMA = 0.71 - 0.125 \text{ days on ice}$$

$$R^2 = 87.2\%$$

f) For redfish:

$$\log 1/TMA = 0.87 - 0.116 \text{ days on ice}$$

$$R^2 = 89.7\%$$

When computing the above mentioned equations, results from all experiments were used in each instance. Checks for significant variation between experiments showed that the significant differences between experiments with line-caught fish changed to not significant, if weight was taken into account.

This is because fish decay with somewhat different rapidity, depending on size. Significant differences between experiments with net-caught fish and redfish diminished if weight was taken into account, but did not disappear. The fish presumably decayed with somewhat varying rapidity in spite of attempts made to standardize all storage conditions.

A close look at the results of TMA measurements showed that despite very good correlation to days on ice, TMA in line-caught fish does not rise as much as expected after such extended storage on ice. TMA measurements are frequently used in this country to support physical appraisal. The general estimate used is TMA = 10 mg N/100g. According to the above equations, the TMA level reached 10 on average after 16½ days on ice, but after scarcely 14 days on ice in net-caught fish, and after 16 days in redfish. It has been noted in other countries that TMAO in fish varies according to size and age of the fish, place of harvest and time of year. Measurements of TMAO were carried out on cod in November and April, and on redfish in June, with the results shown in Table 3.

These variations in TMAO in cod partly explain the moderate TMA spread in November. The bacterial flora in fish also varies with time of year.

### 3.5. Cut-off point for processing and comparison between methods

It is to be expected that the RT freshness grader very often will be used to determine the processing fitness of fish, e.g. when positioned before the sorting machine in the freezing plant. A high degree of correlation has previously been shown between various methods and the period of storage on ice, but as can be seen, the scatter of results is considerable (figure 1). In an attempt to define the actual significance of this scatter, figure 3 shows how the various appraisal methods compare with regard to the processing fitness of line-caught cod. Only one conclusion can be drawn. Examination of the results of experiments on line-caught cod show that when assessed by physical appraisal, most fish are deemed unfit by day 11, and all by day 13. As already mentioned, TMA levels found were very moderate in experiments with line-caught fish and correlated very well with physical appraisal in net-

caught fish. By selecting day 11 as processing cut-off and inserting it into the above mentioned equations a-f, a definitive cut-off point was obtained for RT and TMA measurements and physical appraisal. After determining the cut-off point, the percentage of fish fit for processing was computed independently for each method and shown in figure 3. As can be seen, the fish has been classified by period of storage on ice. This manner of classification was considered more practical since fish of widely different age are rarely dealt with together. This diagram shows some lack of correlation between RT results and odour appraisal for fish stored 10-12 days on ice. The RT freshness grader classifies over 80% of these fish as unfit [sic], while the figure for odour appraisal is about 74%. It is very difficult to say whether one is more correct than the other.

To determine which point to choose as cut-off for freezing purposes, several similar diagrams (not shown here) were examined showing different cutoff points for processing, e.g. 10-13 days on ice. Ultimately selected as cutoff for processing was the point which in the diagram showed least divergence between the RT freshness grader, TMA measurements and physical appraisal. This procedure showed that on the RT freshness grader, 7.7 for line-caught cod, 7.3 for net-caught cod and 7.2 for redfish were the points that diverged least from the odour appraisal. Naturally, the appraiser's working experience will also tell him where to set the cut-off.

**4. Discussion**

There is no absolute criterion for the freshness and shelf life of fish, but in the experiments here described, four different methods were used which all provide information on fish freshness. We have attempted to compare these methods. The general point of reference was the period of storage on ice as being the most practical criterion for determining the condition of fish. One observation was that size has some bearing on how rapidly a fish decays. The correlation level between RT measurements and days on ice was higher than for odour appraisal, but slightly below the results of TMA measurements. The correlation between RT measurements and days on ice may be regarded as linear. The correlation between TMA results and days on ice can likewise be regarded

as linear, provided log 1/TMA is applied against days on ice. Correlation between RT measurements and TMA measurements is also very high. Notwithstanding the good relative correlation demonstrated by linear equations between these methods as well as to storage period on ice, results show some scatter around the linear axis.

The Torry Research Station report[1] discusses measurements with the hand-operated Torry grader on about 2,000 fish, mainly on 5 fish species of lean fish at different times of the year. Results show differences related to fish species and time of harvest, but not to whether the fish were bled after death or live. It was also shown that if the fish were handled with reasonable care, treatment did not influence the interpretation of results. It was reported that rising temperature in the fish during several hours after the onset of rigor mortis and before icing reduced the readability of results. All indications are that the present automatic device provides equally good results as the hand-operated Torry grader.

We can confidently assert that the RT freshness grader shows much promise as far as freshness measurement on cod and certain other lean fish species is concerned. The results of last summer's experiments also indicate that the RT freshness grader shows promise in respect of freshness measurements on redfish. The main advantages of the RT freshness grader is that it works quickly, grading some 60-70 fish per minute, does not damage the fish and requires no trained operators.

## 5. References


1. Jason, A.C. and Lees, A. Estimation of fish freshness by dielectric measurement, Torry Research Station, Aberdeen 1971.

2. Emilía Martinsdóttir, Investigation of the shelf life of cod by means of the RT freshness grader, TMA measurements and physical appraisal. Fishing Industry Research Station 1986.


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The author is a chemical researcher at the Fishing Industry Research Station.


Photographs show the RT freshness grader at Vinnslustödin in Vestmannaeyjar.

Table 1.
Freshness and weight measurements with the RT freshness grader

| | RT scores | | Average weight | |
|---|---|---|---|---|
| | Average | SD % | kg | SD |
| Line-caught cod | 11.95 | 8.5 | 3.40 | 1.4 |
| Net-caught cod | 12.41 | 5.1 | 3.06 | 0.6 |
| Redfish | 10.90 | 9.5 | 0.76 | 0.2 |

Table 2.
Correlation coefficients r

| | | Correlation coefficients r | | |
|---|---|---|---|---|
| Type of fish | Method | Days on ice | RT | LOG 1/TMA |
| Line-caught cod | | - 0.91 | | |
| Net-caught cod | RT | - 0.93 | | |
| Redfish | | - 0.91 | | |
| Line-caught cod | | - 0.93 | 0.90 | |
| Net-caught cod | LOG 1/TMA | - 0.94 | 0.91 | |
| Redfish | | - 0.95 | 0.87 | |
| Line-caught cod | | 0.88 | - 0.86 | - 0.89 |
| Net-caught cod | ODOUR | 0.90 | - 0.89 | - 0.91 |
| Redfish | | 0.86 | - 0.83 | - 0.86 |

Table 3.
Measurements of trimethylamine oxide TMAO

| Type of fish, harvest period | TMAO mg N/100 g | No. tested |
|---|---|---|
| Cod, November | 55-60 | 20 |
| Cod, April | 80-85 | 12 |
| Redfish, June | 80-85 | 10 |

CORRELATION BETWEEN RT MEASUREMENTS AND PERIOD OF STORAGE ON ICE
LINE-CAUGHT FISH

RT
SCORES

DAYS ON ICE

Figure 1: Results of RT measurements on line-caught cod compared to period of storage on ice.

CORRELATION BETWEEN RT MEASUREMENTS AND PERIOD OF STORAGE ON ICE
REGRESSION ANALYSIS

RT
SCORES

DAYS ON ICE

--- NET-CAUGHT COD --- LINE-CAUGHT COD --- REDFISH

Figure 2: RT measurements on line-caught cod, net-caught cod and redfish correlated with period of storage on ice.

% OF FISH SUITABLE FOR PROCESSING
CUT-OFF POINT FOR PROCESSING: 11 DAYS

% SUITABLE
FOR PROCESSING

DAYS ON ICE

[ ]] RT = 7.15 [ ] TMA = 2.5 mg N/100G [ ] ODOUR=2.7

Figure 3: Proportion of fish suitable for processing as assessed by RT grading, TMA measurement and physical appraisal; cut-off point for processing is set at 11 days.